

Mangrove-associated macroalgae and cyanobacteria in Shark Bay, Western Australia

J M HUISMAN^{1,2}, A J KENDRICK³ & M J RULE³

¹Western Australian Herbarium, Department of Parks and Wildlife, Locked Bag 104, Bentley Delivery Centre, WA 6983, Australia
✉ John.Huisman@dpaw.wa.gov.au

²School of Veterinary and Life Sciences, Murdoch University, Murdoch, WA 6150, Australia

³Marine Science Program, Department of Parks and Wildlife, Kensington, WA 6151, Australia

A taxonomic survey of the macroalgae and cyanobacteria associated with pneumatophores of the mangrove *Avicennia marina* in Shark Bay, Western Australia, recorded 51 species, comprising 7 Cyanobacteria (blue-green algae), 14 Chlorophyta (green algae), 3 Phaeophyceae (brown algae) and 27 Rhodophyta (red algae). Of these, 31 represent new records for Shark Bay, and the red algae *Gelidium minisculum*, *Bostrychiocolax australis* (a parasite on *Bostrychia radicans*), and *Dasya kristeniae* are newly recorded for Western Australia.

KEYWORDS: *Avicennia marina*, epiphyte, macroalgae, pneumatophores, range extensions, Shark Bay

INTRODUCTION

Shark Bay is a large marine embayment located in Western Australia's semi-arid mid-west. The bay is geologically recent and is separated from the Indian Ocean on its western side by a ridge of Pleistocene Tamala limestone that forms the Zuytdorp Cliffs, Steep Point and the western side of Dirk Hartog Island (Playford 1990). The underlying geology of the region is largely covered by Pleistocene and Holocene sediments that now dominate marine and terrestrial habitats across much of the bay. Shark Bay's typically shallow marine environment comprises western and eastern gulfs separated by the Peron Peninsula. The complex bathymetry formed by channels, banks and sills constrains circulation and contributes to the persistence of hypersaline conditions in the south-eastern reaches at L'haridon Bight and Hamelin Pool. These features are markedly different to the adjacent high-energy oceanic environment and the bay is recognized as being biogeographically unique in the region (DEH 2006).

The distinctive physical and biological features of Shark Bay have led to the region's inclusion on the World Heritage List (whc.unesco.org), and the WA Government manages the bay's world heritage values under an agreement with the Australian Government. Conservation values are also managed by inclusion of marine and terrestrial areas in WA's reserve system, including the Shark Bay Marine Park and Hamelin Pool Marine Nature Reserve which were created in 1990 and comprise ca. 750 000 ha (CALM 1996).

Seagrasses and soft sediments form the major marine benthic habitats in Shark Bay, along with smaller areas of sponge-dominated habitat, corals and mangrove. The limited presence of marine rocky substrata means that macroalgal communities are not a prominent benthic feature as they are along the adjacent coast. Macroalgae occur on limited areas of rocky reef and pavement at

mostly western locations in the bay, as epiphytes on seagrasses and mangroves, and where they have colonized artificial structures like jetties and piers. A review by Huisman *et al.* (1990) documented 153 species of marine algae from Shark Bay.

A sole mangrove species, the Western white mangrove *Avicennia marina* var. *marina* (Fig. 2a, b), inhabits Shark Bay, which is the southern-most location where it forms extensive growth in WA. A general account of *A. marina* in Shark Bay is given in Kendrick *et al.* (2009). About 1,500 ha of *A. marina* exists in dense but often isolated stands around the bay, most of which are less than 10 ha in size and few of which exceed 100 ha (DPaW data). Notably, these trees and their pneumatophores can form a significant source of intertidal hard substratum across large parts of this sand-dominated bay where rocky substrata are scarce.

The suite of algal epiphytes associated with mangrove pneumatophores typically includes species associations that are rarely found in other habitats. Genera commonly found on (but not exclusive to) mangroves include the red algae *Bostrychia* and *Caloglossa*, plus a selection of generalist epiphytes such as *Spyridia filamentosa*, *Anotrichium tenue* and *Sphacelaria rigidula*. As part of a study of *A. marina* in the Shark Bay Marine Park, we undertook a taxonomic survey of the associated epiphytes, primarily to document their presence but also to examine whether species or species associations were unique to particular sites within the bay.

MATERIALS AND METHODS

Field work was undertaken during June 2009 and 13 sites of relatively dense mangrove growth were selected at spatially dispersed locations across Shark Bay (Fig. 1). At each site the occurrence of epiphytes was noted and where possible photographed *in-situ*. Representative samples of epiphyte-bearing pneumatophores were collected and preserved in a 5% Formalin/seawater solution. In the laboratory, larger epiphytes were pressed

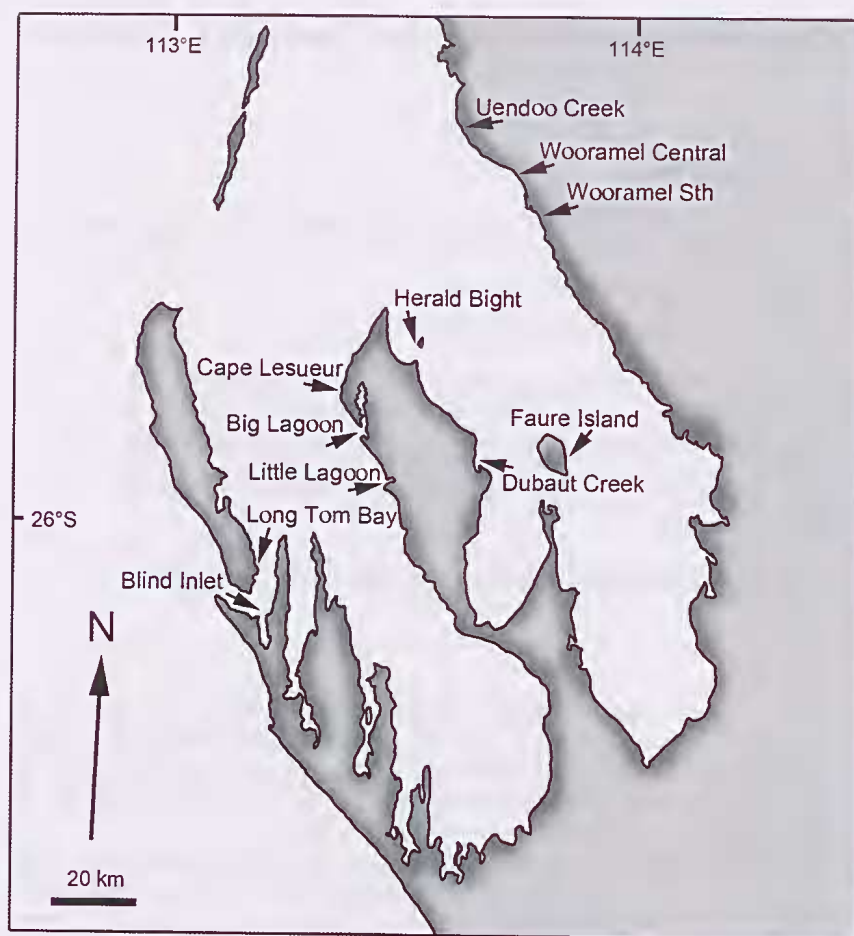


Figure 1. Map of Shark Bay showing collection localities.

onto herbarium sheets, while smaller specimens were mounted whole on microscope slides. Where necessary for microscopic examination, specimens were hand-sectioned, stained in aniline blue, and mounted in a solution of 50% Karo syrup and freshwater. Microscope preparations were examined and photographed using either a Nikon SMZ800 stereo microscope or a Nikon Eclipse 80i compound microscope, in both cases with a Nikon DS Fi1 digital camera. All herbarium sheets and microscopic preparations have been lodged in the Western Australian Herbarium (PERTH). The distribution of species at the various sites (Table 1) is based on presence as observed during the survey, and on subsequent laboratory examination of smaller species.

Only species intimately associated with pneumatophores were recorded. These were growing either directly on the pneumatophores (primary epiphytes) or attached to these primary epiphytes (secondary epiphytes). Some taxa (such as *Chaetomorpha*) were mostly unattached and entangled amongst the pneumatophores.

Taxa were identified based on morphology and agree with previously published accounts of the relevant species. In several cases, particularly in the Cyanobacteria, the identifications are tentative and confirmation by molecular analyses is highly desirable.

Arrangement of the taxonomic account

Taxonomic results are grouped into Cyanobacteria (= blue-green algae), Phaeophyceae (= brown algae),

Chlorophyta (= green algae), and Rhodophyta (= red algae), with constituent species listed alphabetically. This arrangement generally follows that of Huisman *et al.* (2011). For each species, the name, authority, and date and page of publication are given (the place of publication listed in the references), with author names abbreviated according to Brummitt & Powell (1992). Species newly recorded for Shark Bay are marked with an asterisk (*). The PERTH voucher is cited, followed by a comments section. Descriptions of specimens are based on the Shark Bay material. Unless otherwise indicated by 'epiphytic on...', the algae were growing directly on the *Avicennia marina* pneumatophores.

PREVIOUS RECORDS

The diversity of mangrove-associated algae in Shark Bay has not been studied intensively, but several species from the bay have been recorded in monographs and other studies. King & Puttock (1994a, b) surveyed Australian mangrove-associated red algae and recorded *Bostrychia moritziana*, *B. radicans*, *Caloglossa leprieurii*, *Polysiphonia scopulorum*, *Caulacanthus indicus* and *Gelidium* spp. for the region extending from Cape Cuvier to Cape Naturaliste, but no records specifically attributed to Shark Bay were included. Two species of *Bostrychia* often found on mangrove pneumatophores, *B. radicans* and *B. moritziana*, were recorded from Steep Point, Shark Bay, by King & Puttock (1989), although specific habitat details were not given. The collector of these specimens was Fred Wells, at the time with the Western Australian Museum, who



Figure 2. Habitat views and *in-situ* specimens. a. The mangrove *Avicennia marina* growing on the coast near Uendoo Creek. A dense stand of pneumatophores can be seen in the foreground. b. Pneumatophores from the Herald Bight stand, with no epiphyte growth. c. *Acetabularia peniculus* on pneumatophores at Wooramel Central. d. *Ulva flexuosa* on pneumatophores at the seaward edge of Big Lagoon. e. The leafy green *Gayralia oxysperma* on pneumatophores at the same site. f. A dense band of *Caloglossa leprieurii* on pneumatophores at Uendoo Creek. g. Close view of *Bostrychia flagellifera*.

Table 1. Algae and cyanobacteria epiphytic on *Avicennia marina*, Shark Bay, June 2009.

	Uendoo Creek	Wooramel Central	Wooramel South	Little Lagoon	Big Lagoon	Cape Lesueur	Dubaut Creek	Herald Bight	Faure North East	Faure South	Blind Inlet West	Blind Inlet East	Long Tom Bay
<i>Acetabularia peniculus</i>		X	X										
<i>Aglaothamnion cordatum</i>		X		X									
<i>Anotrichium tenue</i>	X			X									
<i>Blastophlysa rhizopus</i>			X										
<i>Boodleopsis siphonacea</i>		X								X			X
<i>Bostrychia flagellifera</i>									X	X	X	X	X
<i>Bostrychia moritziana</i>													X
<i>Bostrychia radicans</i>	X												
<i>Bostrychia tenella</i>	X		X	X						X			X
<i>Bostrychiocolax australis</i>	X												
<i>Caloglossa leprieurii</i>	X		X	X						X			X
<i>Caloglossa monosticha</i>	X						X						
<i>Calothrix aeruginea</i>				X		X							
<i>Catenella nipae</i>	X		X							X			
<i>Centroceras sp.</i>		X	X	X									
<i>Chaetomorpha ligustica</i>	X						X			X	X	X	X
<i>Chondria succulenta</i>			X	X									
<i>Cladophora patentiramea</i>				X									X
<i>Cladophora rupestris</i>				X									
<i>Cladophora vagabunda</i>		X	X	X									X
<i>Crouania sp.</i>			X										
<i>Coleofasciculus chthonoplastes</i>													X
<i>Dasya kristeniae</i>				X									
<i>Dichothrix utahensis</i>				X									
<i>Dictyota furcellata</i>		X											
<i>Erythrotrichia carnea</i>	X		X	X		X			X				
<i>Gayliella fimbriata</i>						X							
<i>Gayralia oxysperma</i>					X			X					
<i>Gelidium mivisculum</i>	X												
<i>Griffithsia heteromorpha</i>				X									
<i>Herposiphonia pacifica</i>	X			X		X							
<i>Herposiphonia tenella</i>		X		X									
<i>Laurencia sp.</i>				X									
<i>Lyngbya semiplena</i>					X	X							
<i>Myrionema sp.</i>	X			X									
<i>Myxolyella papuana</i>													X
<i>Polysiphonia infestans</i>		X	X	X		X			X	X			
<i>Polysiphonia scopulorum</i>	X			X									
<i>Polysiphonia teges</i>				X									
<i>Polysiphonia sp.</i>													
<i>Rhizoclonium riparium</i>	X	X			X	X	X			X			X
<i>Rivularia atra</i>								X					
<i>Scytonema crispum</i>		X				X	X	X	X	X	X	X	X
<i>Sphaecelaria rigidula</i>	X			X		X							
<i>Spyridia filamentosa</i>		X	X	X						X			
<i>Stylonema alsidii</i>		X	X										
<i>Ulva flexuosa</i>					X						X		
<i>Ulva paradoxa</i>	X		X		X	X			X	X		X	
<i>Ulvella leptochaete</i>			X	X									
<i>Ulvella viridis</i>				X									
<i>Uronema marinum</i>									X	X			X

recalled (pers. comm., 1 Mar. 2012) that the specimens were indeed epiphytic on mangroves.

Kendrick *et al.* (1990: 48) noted that collections of epiphytes were made from the pneumatophores of the mangrove *Avicennia marina* in Shark Bay during 1986. They listed *Ulvaria oxysperma* [= *Gayralia oxysperma*], *Caloglossa leprieurii*, *Spyridia filamentosa*, *Bostrychia moritziana*, *B. radicans* and *B. tenella* ssp. *flagellifera* [= *Bostrychia flagellifera*], but no collection data were given. These records were provided by Robert King, who identified the specimens (Kendrick *et al.* 1990: 53). Huisman *et al.* (1990) collated new and published records of macroalgae from Shark Bay, but did not include the mangrove epiphytes mentioned by Kendrick *et al.* (1990).

Kamiya *et al.* (1997) described the new species *Caloglossa monosticha*, with the type locality of Derby, Western Australia. They also cited a specimen from 'Small' [presumably Little] Lagoon, Denham, collected in 1991. The specific habitat of this Shark Bay specimen was not stated, but the species was described as "often epiphytic on mangroves" (p. 104).

Finally, the molecular phylogenetic analysis of *Caloglossa* species by West *et al.* (2001: 187, Table 2) included *C. leprieurii* from Shark Bay (specific location not given) and *C. monosticha* from Monkey Mia, Shark Bay.

RESULTS

Key to the major groups of mangrove-associated macroalgae and cyanobacteria at Shark Bay

- 1 Thallus blue-green to dark green, forming unbranched or falsely branched filaments, in some with heterocytes; cells prokaryotic, lacking organelles, but occasionally granular in appearance **Cyanobacteria**
- 1: Thallus various shades of green, red or brown, with simple or complex construction, without heterocytes; cells eukaryotic, with organelles 2
 - 2 Thallus grass green **Chlorophyta**
 - 2: Thallus other colours 3
- 3 Thallus brown **Phaeophyceae**
- 3: Thallus red **Rhodophyta**

Cyanobacteria (blue-green algae)

Numerous unicellular and filamentous cyanobacteria were present on the *Avicennia* pneumatophores. The present treatment only deals with the conspicuous taxa.

Key to the mangrove-associated Cyanobacteria at Shark Bay

- 1 Trichomes aggregated in a common sheath or mucilage 2
- 1: Trichomes not aggregated 4
 - 2 Trichomes without heterocytes **2. *Coleofasciculus chthonoplastes***
 - 2: Trichomes with heterocytes 3
- 3 Trichomes with false branching, 1- many in a branched sheath **3. *Dichothrix utahensis***

- 3: Trichomes aggregated in a mucilage hummock **6. *Rivularia atra***
- 4 Trichomes with heterocytes 5
- 4: Trichomes without heterocytes 6
- 5 Heterocytes intercalary, filaments with occasional false branching **7. *Scytonema crispum***
- 5: Heterocytes basal, filaments unbranched **1. *Calothrix aeruginea***
- 6 Filaments branched, prostrate on larger algae .. **5. *Myxohyella papuana***
- 6: Filaments unbranched, generally entangled amongst other algae **4. *Lyngbya semiplena***

1. *Calothrix aeruginea* Thur. ex Bornet & Flahault 1886: 358.*

Filaments 200–250 µm long, with a basal heterocyte. Sheath 10–12 µm diam. near base, tapering distally. Trichomes basally 7–10 µm diam., tapering gradually and evenly to the apices. Basal heterocyte dome-shaped, 7–10 µm diam (Fig. 3a).

Specimen: Herald Bight, seaward side, on basal region of *Gayralia oxysperma*, 8 June 2009, J.M.Huisman (PERTH 08578699).

The specimens closely match the description of this species in Whitton (2011).

2. *Coleofasciculus chthonoplastes* (Thur. ex Gomont) Siegesmund, J.R.Johans. & Friedl. 2008: 1575.*

Thallus blue-green, with several trichomes united in a common sheath. Trichomes unbranched, slightly constricted at the cross walls, 5–9 µm diam. Cells L:B ±1.5–2, not tapering, apical cell with rounded apex, noncalyptrate (Fig. 3b).

Specimen: Long Tom Bay, South Passage, 11 June 2009, J.M.Huisman (PERTH 08578796).

The present specimen agrees morphologically with the description of this apparently widespread species by Siegesmund *et al.* (2008), but the identification should be confirmed by molecular analyses.

3. *Dichothrix utahensis* Tilden 1898 [1894–1909]: 288.*

Thallus forming upright tufts of one to numerous trichomes in a common branched sheath, the basal segment comprised of a single trichome, more distal segments with progressively increasing numbers of trichomes due to addition by false branching. Trichomes 2–7 µm diam., tapering to pointed apices that emerge from the sheath, cells L:B 0.2–10 (shortest near apices). Heterocytes basal on false branches, unipolar, dome-shaped, 5–12 µm diam., L:B 0.5–1, or intercalary and bipolar, to 20 µm long and 7 µm diam. (Figs 3c, d).

Specimens: Little Lagoon, 6 June 2009, J.M.Huisman (PERTH 08578702).

The specimens agree with the description of this species from the Caribbean by Littler & Littler (2000), which was also of thalli growing on mangrove prop roots. Amongst the species they recorded, *D. utahensis* was characterized by its narrow heterocytes (10–16 µm diam.) and the presence of intercalary as well as basal heterocytes, both

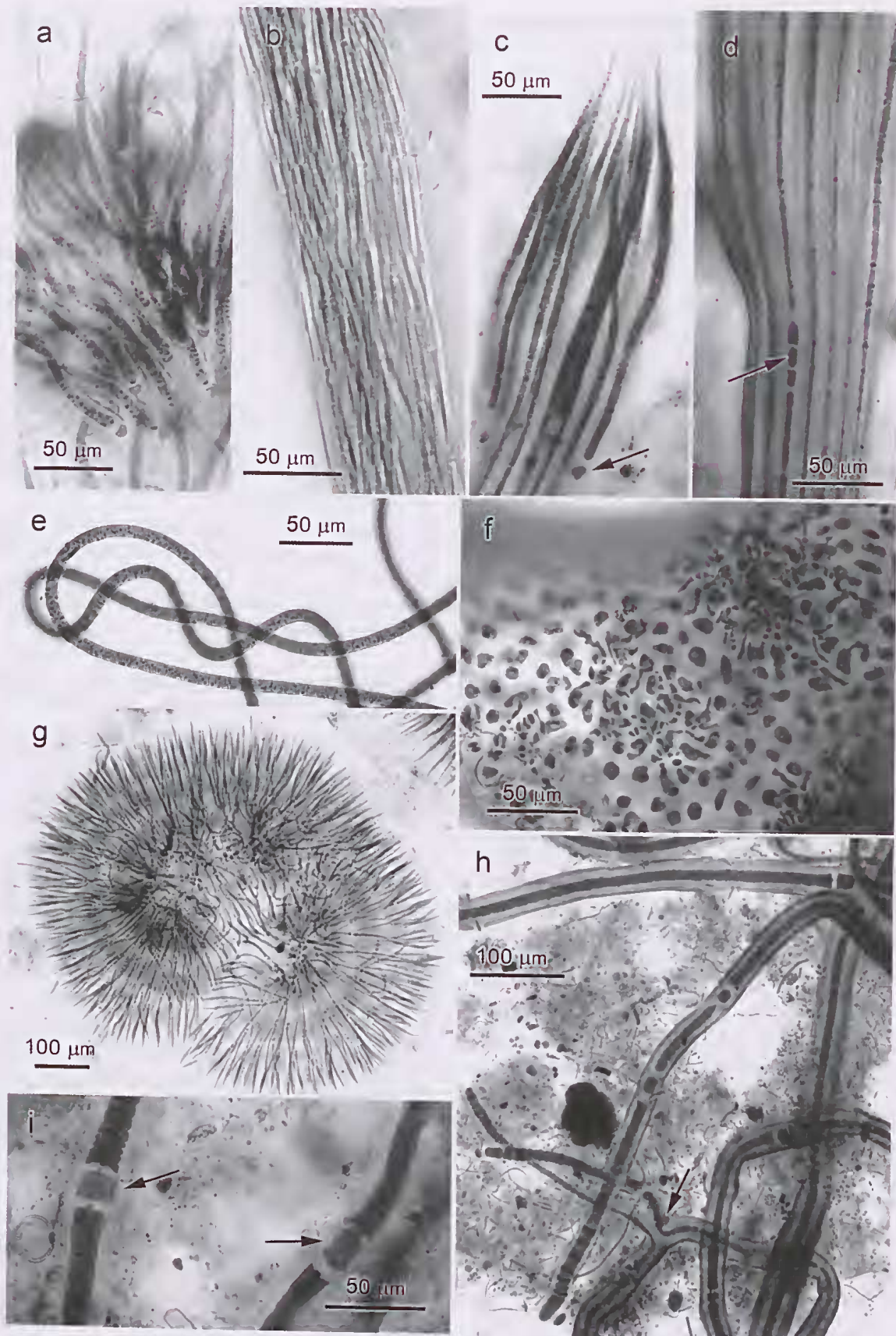


Figure 3. Cyanobacteria. a. *Calothrix aeruginea*, with clustered tapering trichomes and basal heterocysts. b. *Coleofasciculus chilonoplastes*, with numerous trichomes in a common sheath. c. *Dichothrix utahensis*, the wick-like upper region. d. *Dichothrix utahensis*, mid region with trichomes in a common sheath and intercalary heterocysts. e. *Myxohyella papuana*, branched pseudofilaments growing on the surface of *Bostrychia tenella*. f. *Lyngbya semiplena*. f. *Myxohyella papuana*, branched pseudofilaments growing on the surface of *Bostrychia tenella*. g. *Rivularia atra*, polar view of hemispherical colonies. h, i. *Scytonema crispum*. h. showing plate-like cells and conspicuous heterocysts (arrows). i. with false branching (arrow).

features of the Shark Bay material. The species was subsequently recorded from Wake Atoll in the central Pacific by Tsuda *et al.* (2010).

4. *Lyngbya semiplena* J.Agardh ex Gomont 1892: 138.*

Forming tangled mats. Filaments straight or occasionally coiled, unbranched, 7–12 µm diam., sheath inconspicuous. Cells discoid, L:B 0.2–0.3, with or without a terminal calyptra. Necrida common (Fig. 3e).

Specimen: Cape Lesueur, 7 June 2009, *J.M.Huisman* (PERTH 08578680).

This is a seemingly cosmopolitan species, found in coastal regions worldwide

5. *Myxohyella papuana* L.Hoffm. 1992: 318.*

Thallus blue-green, minute, 50–100 µm broad, prostrate and partly endophytic on *Bostrychia tenella*, with branched pseudofilaments. Central region of angular to rounded, mostly equidimensional cells, 3–5 µm diam. Peripheral cells elongate, L:B 2–7, often irregularly shaped and following the contours of the host cells (Fig. 3f).

Specimen: South Passage, epiphytic on *Bostrychia tenella*, 11 June 2009, *J.M.Huisman* (PERTH 08578575).

This small epiphyte was described from Papua New Guinea, based in part on a specimen 'endophytic in a red alga growing on the roots of mangrove trees in the intertidal zone'.

6. *Rivularia atra* Roth ex Bornet & Flahault 1886: 353.*

Colonies forming hemispherical hummocks, to 2 mm diam., formed by aggregated *Calothrix*-like filaments. Trichomes 150–400 µm long, with a dome-shaped basal heterocyte, ± 5 µm diam., then cells of similar diameter, L:B 0.5–1, gradually tapering to a hair-like apex (Fig. 3g).

Specimen: Little Lagoon, 6 June 2009, *J.M.Huisman* (PERTH 08578710).

Rivularia is a colonial organism formed of *Calothrix*-like trichomes embedded in mucilage.

7. *Scytonema crispum* Bornet ex Forti 1907: 498.*

Thallus tufted, to a few mm tall, often accumulating mud and other debris. Filaments mostly tortuous, occasionally straight, rarely with false branching, 25–35 (-50) µm diam., of fairly uniform width. Trichome blue-green, often filling sheath, especially near apices, to 15–25 µm diam., cells L:B 0.1–0.3, often considerably more slender in lower portions, to 3–7 µm diam., L:B up to 2, and occupying ± 15% of the sheath. Apices rounded or tapering, often with a cap-like apical cell. Heterocytes conspicuous, intercalary, with diameter similar to that of adjacent cells, L:B 0.5–2 (Figs 3h, i).

Specimen: Dubaut Creek, 8 June 2009, *J.M.Huisman* (PERTH 08578451).

This species forms dense tufts on the pneumatophore surface. The false branching and presence of heterocytes places it in the genus *Scytonema*, but most species in the genus have considerably more slender filaments. The specimens agree well with the description in Whitton

(2011), although he recorded only freshwater habitat and the determination is therefore tentative. King & Wheeler (1985) recorded *Scytonema crispum* (C. Agardh) Bornet occurring as dense tufts on pneumatophores at Stuarts Point, N.S.W. An invalidly described species, *Scytonema hamelinii* Gebelein (in Logan, Hoffman, & Gebelein, 1974: 146, 194) was recorded from Hamelin Pool, Shark Bay. This species was presumably not a mangrove epiphyte and we are unaware of any extant material.

Chlorophyta

Key to the mangrove-associated Chlorophyta at Shark Bay

- 1 Thallus microscopic, single-celled, endophytic or epiphytic on larger algae **9. *Blastoptysa rhizopus***
- 1: Thallus microscopic or macroscopic, multicellular or siphonous 2
 - 2 Thallus microscopic 3
 - 2: Thallus macroscopic 5
- 3 Thallus with prostrate branched filaments 4
- 3: Thallus with upright unbranched filaments **21. *Uronema marinum***
 - 4 Filaments closely arranged; cells with hairlike extensions **19. *Ulvella leptochaete***
 - 4: Filaments with intervening spaces; cells lacking hairlike extensions **20. *Ulvella viridis***
- 5: Thallus radially symmetrical, with a central stalk and apical crown of gametangial rays **8. *Acetabularia peniculus***
- 5: Thallus not radially symmetrical, of other form 6
 - 6 Thallus with discrete cells 7
 - 6: Thallus branched but lacking discrete cells (siphonous construction) **10. *Boodleopsis siphonacea***
- 7 Thallus filamentous, unbranched 8
- 7: Thallus filamentous and branched, or of other structure 9
 - 8 Cells 70–100 µm in diameter **11. *Chaetomorpha ligustica***
 - 8: Cells 15–35 µm in diameter **16. *Rhizoclonium riparium***
- 9 Thallus filamentous, branched, never multiseriate, 10
- 9: Thallus membranous or tubular, or partly multiseriate with uniseriate apices 12
 - 10 Thallus forming decumbent clumps, with arching filaments **13. *Cladophora patentiramea***
 - 10: Thallus mostly upright 11
- 11 Thallus with percurrent primary axis and often opposite lateral branches; not falcate near apices **14. *Cladophora rupestris***
- 11: Thallus generally with only one lateral branch per cell; falcate near apices **12. *Cladophora vagabunda***
 - 12 Thallus membranous .. **15. *Gayralia oxysperma***
 - 12: Thallus not membranous 12
- 13 Thallus lacking uniseriate branches .. **17. *Ulva flexuosa***
- 13: Thallus with uniseriate branches near apices **18. *Ulva paradoxa***

8. *Acetabularia peniculus* (R. Brown ex Turner) Solms-Laubach 1895: 27.

Thallus generally with several upright axes in a cluster, pale green or whitish from calcification, to 10 cm tall, with several whorls of colourless branched hairs and an apical whorl of 10–18 green gametangial rays, these basally attached but not laterally joined. Gametangial rays clavate, 2–5 mm long and 0.5–3.0 mm broad, when fertile with numerous spherical gametangial cysts 240–270 µm diam. (Fig. 2c).

Specimen: Wooramel central, 5 June 2009, J.M. Huisman (PERTH 08578419).

Acetabularia peniculus is a common species that is often found growing in clusters on old bivalve shells on sandy substrata. This represents the first record of this species as a mangrove epiphyte. The species was included in the earliest records of marine algae from Shark Bay (Quoy & Gaimard 1824: 159, as *Polyphyssa peniculus* from 'Baie des Chiens-Marins')

9. *Blastophysa rhizopus* Reinke 1889: 87.*

Individual, irregularly shaped, green cells, 35–50 µm broad, epiphytic on *Bostrychia tenella*.

Specimen: Wooramel, epiphytic on *Bostrychia tenella*, 5 June 2009, J.M. Huisman (PERTH 08578591).

This is a small epi/endophyte that is often associated with larger red algae.

10. *Boodleopsis siphonacea* A. Gepp & E. Gepp 1911: 64.*

Thallus tufted, dark green, to 5 mm tall, with prostrate and irregularly constricted siphons 50–75 µm diam., attached by tapering rhizoids 8–20 µm diam.; erect siphons terete, 17–25 µm diam. Branches 50–900 µm long, more elongate distally, evenly constricted at branch bases and often with slight constrictions elsewhere (Figs 4a, b).

Specimens: Faure I., Shark Bay, 10 June 2009, J.M. Huisman (PERTH 08578478); Blind Inlet, South Passage, Shark Bay, 11 June 2009, J.M. Huisman (PERTH 08578486).

This species is apparently known only from the type collection, but other species recorded from elsewhere might be synonymous. Species of *Boodleopsis* are distinguished by features such as habit, density of branching, and frequency of constrictions, which appear to overlap in many cases. Skelton & South (2002) described similar specimens from mangroves in Samoa, which they ascribed to *B. carolinensis* Trono, a species separated from *B. siphonacea* largely by its more densely branched habit (Trono 1971).

11. *Chaetomorpha ligustica* (Kütz.) Kütz. 1849: 376.*

Thallus grass green, generally entangled amongst other algae or cyanobacteria, composed of unbranched filaments. Cells 70–100 µm diam., L:B 1–3, intercalary divisions common and forming pairs of daughter cells. Parietal reticulate plastids with numerous pyrenoids. Rarely with attachment rhizoids (Fig. 3d) similar to those found in *Rhizoclonium* (Figs 4c, d).

Specimen: Long Tom Bay, 11 June 2009, J.M. Huisman (PERTH 08578400).

These specimens agree with Womersley's (1984) concept of *Chaetomorpha capillaris* (Kütz.) Borgesen, a species now regarded as a taxonomic synonym of *Chaetomorpha ligustica* (see Leliaert & Boedeker 2007: 142). Cribb (1965) treats this species as the basionym *Rhizoclonium capillare*, based on the presence of attachment rhizoids similar to those found in the present material, but Womersley (1984) doubted the specific identity of Cribb's material. Beanland & Woelkerling (1982: 94) recorded this species (as *C. capillaris*) on *Avicennia* pneumatophores in South Australia.

There is considerable uncertainty regarding specific identities of *Chaetomorpha* and *Rhizoclonium* species, and it is likely that several cryptic species are involved. Thus application of this name must be regarded as tentative in the absence of DNA sequence analyses.

12. *Cladophora patentiramea* (Mont.) Kütz. 1849: 416.*

Thallus forming a tuft, attached at several points, with arching, irregularly branched filaments. Rhizoids arising as projections from proximal end of bearing cell. Lateral branches initially in open connection with parent cell, later forming a cross-wall. Cells 70–160 µm diam., elongate, L:B up to 10.

Specimen: Long Tom Bay, South Passage, 11 June 2009, J.M. Huisman (PERTH 08578753).

13. *Cladophora rupestris* (L.) Kütz. 1843: 270.*

Thallus dark green, attached by digitate processes arising from the basal cell. Primary axis percurrent, with cells 70–100 µm diam., L:B 1–4, each generally with (1-) 2 (-3) opposite lateral branches, occasionally naked (Fig. 4e).

Specimen: Wooramel, epiphytic on *Bostrychia tenella*, 5 June 2009, J.M. Huisman (PERTH 08578745).

This distinctive species has dark green percurrent primary axes from which lateral branches arise in opposite pairs.

14. *Cladophora vagabunda* (L.) C. Hoek 1963: 144.

Thallus upright, grass green, filamentous, generally branched every 1–2 cells but often with intercalated unbranched cells. Branching falcate near apices. Cells 70–80 µm diam. near base, tapering to 20–25 µm diam.

Specimen: Faure I., 10 June 2009, J.M. Huisman (PERTH 08578443).

The dimensions of these specimens fall within *Cladophora dalmatica* Kütz., a species now provisionally treated as a small form of *C. vagabunda* (e.g. Kraft 2007: 81), although molecular analyses will likely result in further revision. Previously recorded for Shark Bay by Huisman *et al.* (1990).

15. *Gayralia oxysperma* (Kütz.) Vinogradova ex Scagel *et al.* 1989: 72.

Thallus grass green, membranous, leafy, to 3 cm tall and equally as broad. Blade one cell thick, in surface view the cells often in packets. Lower cells with basally directed, elongate tails (Figs 2e, 4f).

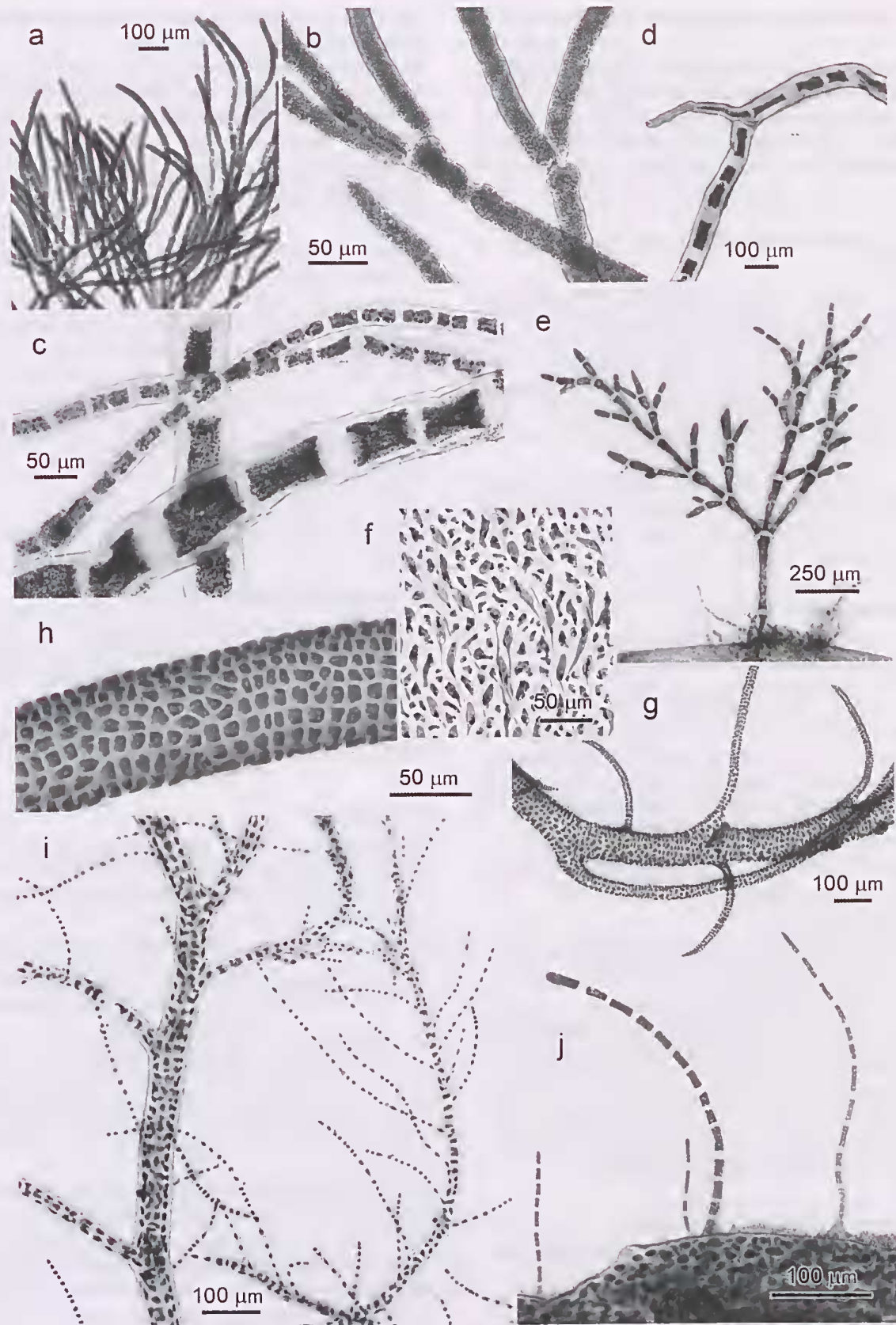


Figure 4. Chlorophyta (green algae). a, b. *Boodleopsis siphonacea*. a. view of upper thallus. b. detail of branching with slight constrictions. c. *Chaetomorpha ligustica* (broad, lower filaments) and *Rhizoclonium riparium* (narrow, upper filaments), often found growing together. d. *Chaetomorpha ligustica*, with attachment rhizoid. e. *Cladophora rupestris*, with branched filaments. f. Surface view of *Gayralia oxysperma*, at the transition to the basal region and showing cells with elongate tails. g, h. *Ulva flexuosa*. g. thallus habit. h. closer view of branch with cells in vague longitudinal rows. Several pyrenoids can be seen in each cell. i. *Ulva paradoxa*, thallus habit, showing numerous uniseriate branches characteristic of this species. j. *Uronema marinum*, simple filaments typical of this species.

Specimen: Big Lagoon, 7 June 2009, *J.M.Huisman* (PERTH 08578427).

The membranous green thallus of *Gayralia oxysperma* superficially resembles that of some leafy species of *Ulva* (see Kendrick *et al.* 2009: unnumbered fig. on p. 55), but it can be readily identified by its blades composed of only a single cell layer, whereas those of *Ulva* have two layers.

16. *Rhizoclonium riparium* (Roth) Harv. 1849: pl. CCXXXVIII.*

Slender unbranched filaments, growing indeterminately (vouchers to 5 mm long), sporadically attached to the pneumatophores by rhizoidal outgrowths from distal ends of cells, these causing the filament to kink. Filaments 15–35 µm diameter, cells L:B 1–3, intercalary divisions common and distinct pairs of daughter cells. Parietal plastids somewhat rod-shaped, with numerous pyrenoids (Fig. 4c).

Specimens: Uendoo Creek, 4 June 2006, *J.M.Huisman* (PERTH 08578672); Faure I., 10 June 2009, 10.17 a.m. *J.M.Huisman* (PERTH); Long Tom, South Passage, 11 June 2009, *J.M.Huisman* (PERTH).

17. *Ulva flexuosa* Wulfen 1803: 1.*

Thallus erect, to 7–8 cm tall, grass-green, attached by a rhizoidal base. Branching primarily from near the base; branches proximally narrow and broadening distally. Structure with cells mostly in longitudinal rows, occasionally also in transverse rows, the alignment of cells more regular near the base and becoming irregular above. Cells in surface view square to rectangular, 10–20 µm wide, each with a parietal chloroplast and 2–4 pyrenoids each 5–6 µm diam. (Figs 4g, h).

Specimen: Big Lagoon, Shark Bay, ocean side, on *Avicennia marina* pneumatophores, 7 June 2009, *J.M.Huisman* (PERTH 08578664).

Ulva flexuosa and *U. paradoxa* were previously included in the now subsumed genus *Enteromorpha*, a genus wherein the thallus was tubular in form rather than sheet-like as in typical *Ulva*. Thalli of *Ulva flexuosa* have tubular branches in which the cells are arranged in longitudinal and often transverse series. Adventitious uniseriate branches arise occasionally to profusely from the tubular branches. Each cell has 2–3 pyrenoids. *Ulva paradoxa* was once regarded as a form of *U. flexuosa*. It differs in the regular occurrence of uniseriate branches, these near apices often with opposite lateral branches.

18. *Ulva paradoxa* C.Agardh 1817: xxii.*

Thallus erect, to 5 cm tall, olive-green to grass-green, tufted, with a rhizoidal base. Primary axes 30–60 µm diam. Branching irregular, most axes with uniseriate lateral branches, these alternate or often opposite, 15–20 µm diam. Cells transversely and longitudinally aligned throughout, although often displaced, 10–35 µm diam. in surface view, each with 2–10 pyrenoids (Fig. 4i).

Specimen: Cape Lesueur, 7 June 2009, *J.M.Huisman* (PERTH 08578273).

19. *Ulvella leptochaete* (Huber) R.Nielsen, O'Kelly & B.Wysor in Nielsen *et al.* 2013: 51.*

Thallus microscopic, prostrate on *Acetabularia peniculus*, composed of branched filaments that generally coalesce to form a partly complete cover. Cells irregularly shaped, 20–35 µm diam., many with hairlike extensions.

Specimen: Wooramel, epiphytic on *Acetabularia peniculus*, 5 June 2009, *J.M.Huisman* (PERTH 08578737).

20. *Ulvella viridis* (Reinke) R.Nielsen, O'Kelly & B.Wysor in Nielsen *et al.* 2013: 53.*

Thallus microscopic, bright green, endophytic in walls of *Polysiphonia teges*, of irregularly branched prostrate filaments to 200 µm long. Filaments generally remaining free, rarely forming a loose pseudoparenchyma. Cells mostly subsodiametric, squarish to rectangular in outline, mostly 10–15 µm diam., but some cells in actively growing regions more slender (c. 5 µm diam.). Cells with a parietal chloroplast and 1 or 2 pyrenoids. Hairs not observed.

Specimen: Little Lagoon, on *Polysiphonia teges*, 6 June 2009, *J.M.Huisman* (PERTH 08578583).

21. *Urouema marinum* Womersley 1984: 131.*

Thallus grass green, with simple filaments to 400 µm tall, 7–17 µm diam., attached basally by a small digitate holdfast. Cells L:B 1.5–4, with one central nucleus and several pyrenoids (Fig. 4j).

Specimen: Faure I, epiphytic on *Bostrychia tenella*, 10 June 2009, *J.M.Huisman* (PERTH 08578761).

Phaeophyceae

The diversity of brown algae was very low, with only *Dictyota furcellata*, *Sphacelaria rigidula* and the small encrusting *Myrionema* sp. encountered.

Key to the mangrove-associated Phaeophyceae at Shark Bay

- 1 Thallus forming discoid crusts, less than 1 mm diam. 23. *Myrionema* sp.
- 1: Thallus upright, not small crusts 2
 - 2 Thallus dichotomously branched, with flat axes 22. *Dictyota furcellata*
 - 2: Thallus tufted, wiry, irregularly branched, with terete axes 24. *Sphacelaria rigidula*

22. *Dictyota furcellata* (C.Agardh) J.Agardh 1848: 90.

Thallus to 8 cm tall, entangled, dichotomously divided every 5–10 mm. Axes flattened, to 1 mm broad below, tapering to 200 µm near apices. Apices pointed, with a prominent apical cell. Hair tufts common. Tetrasporangia scattered or in small groups on surface of thallus, spherical, 75–110 µm diam. (Fig. 5b).

Specimen: Wooramel central, 5 June 2006, *J.M.Huisman* (PERTH 08578370).

Shark Bay is the type locality of this narrow species of *Dictyota*.

23. *Myrionema* sp.*

Thallus epiphytic, discoid, to 350 µm diam., with a monostromatic basal layer of regularly or irregularly radiating filaments, these when mature bearing short upright filaments, phaeophycean hairs, or ascocysts. Basal filaments laterally coherent, except at margins where some are free, with cells quadrate or irregular in shape, 8–10 µm broad, L:B ±1. Phaeophycean hairs to 400 µm long, simple, with a basal meristem subtending hyaline cells 7–10 µm diam., L:B to 10.

Specimens: Little Lagoon, on *Polysiphonia teges*, 6 June 2009, J.M.Huisman (PERTH 08578648).

This is a small discoid epiphyte found on a variety of other algae. The specimens are not adequate for species determination.

24. *Sphacelaria rigidula* Kütz. 1843: 292.

Thallus to 10 mm tall, forming dense dark brown wiry tufts attached by rhizoidal filaments arising from lower axes. Erect axes mostly of similar height; apical cells 25–50 µm diam.; lower segments undergoing several longitudinal divisions, but maintaining a similar diameter throughout the plant, in lateral view showing 1–3 (–4) cells. Lateral branches common, arising at shallow angles and slightly narrowed at the base. Elongate hairs forming laterally near apices of erect axes, 20–25 µm diam., with a basal meristem. Propagules with a primary axis c. 250 µm long, bearing 2 elongate arms and a small dome-shaped cell at the apex (Fig. 5a).

Specimen: Little Lagoon, 6 June 2009, J.M.Huisman (PERTH 08578494).

Rhodophyta*Key to the mangrove-associated Rhodophyta at Shark Bay*

- 1 Thallus filamentous, structurally without pericentral cells, pseudoparenchyma or cortication of any form 2
- 1: Thallus structurally with pericentral cells, pseudoparenchyma or cortication 7
 - 2 Filaments without pit-connections between cells 3
 - 2: Filaments with pit-connections between cells 4
- 3 Thallus unbranched 39. *Erythrotrichia carnea*
- 3: Thallus branched 51. *Stylonema alsidii*
 - 4 Axial cells each with 3 whorl branches 37. *Crouania* sp.
 - 4: Axial cells with fewer than 3 branches 5
- 5 Thallus alternately branched with a single lateral branch per axial cell, without trichoblasts 25. *Aglaothamnion cordatum*
- 5: Thallus sparsely branched, with trichoblasts (colourless hairs) 6
 - 6 Cells mostly of similar form; trichoblasts numerous, very conspicuous 26. *Anotrichium tenue*
 - 6: Cells cylindrical in lower thallus, barrel-shaped to spherical in upper thallus; trichoblasts rudimentary 42. *Griffithsia heteromorpha*
- 7 Thallus cartilaginous, wiry, structurally with longitudinal medullary filaments and a pseudoparenchymatous cortex 8
- 7: Thallus not as above 9
 - 8 Thallus segmented, without rhizines 34. *Cateuella uipae*
 - 8: Thallus not segmented, with rhizines (thick walled internal filaments) 41. *Gelidium minisculum*
- 9 Thallus leafy, with a midrib and lateral wings 10 (*Caloglossa*)
- 9: Thallus not leafy 11
 - 10 Attachment rhizoids forming a stipe; basal axial cell of lateral branches lacking an adaxial pericentral cell 32. *Caloglossa lepreurii*
 - 10: Attachment rhizoids not forming a stipe; basal axial cell of lateral branches with an adaxial pericentral cell 33. *Caloglossa monosticha*
- 11 Forming parasitic pustules on *Bostrychia* 31. *Bostrychiocolax australis*
- 11: Not parasitic 12
 - 12 Branches with pericentral cells (longitudinally oriented cells cut off from the primary axial cells) 13
 - 12: Branches without pericentral cells 25
- 13 Pericentral cells divided transversely ... 14 (*Bostrychia*)
- 13: Pericentral cells not divided transversely 17
 - 14 Thallus with main axes corticate 15
 - 14: Thallus ecorticate throughout 16
- 15 Lateral branches arising from every axial cell on the indeterminate axes 30. *Bostrychia tenella*
- 15: Lateral branches arising from every 2–4(–5) axial cells on the indeterminate axes .. 27. *Bostrychia flagellifera*
 - 16 All branches polysiphonous 29. *Bostrychia radicans*
 - 16: Main branches polysiphonous; ultimate vegetative branches monosiphonous 28. *Bostrychia moritziana*
- 17 Thallus with distinct prostrate axes from which arise upright branches in a regular pattern of determinate and indeterminate branches 18 (*Herposiphonia*)
- 17: Thallus erect, or if prostrate without a regular pattern of branches 19
 - 18 Lateral branches in the repeating pattern: 3 determinate/1 determinate 44. *Herposiphonia tenella*
 - 18: Lateral branches in the repeating pattern: 1 determinate/1 determinate/1–2 naked segments 43. *Herposiphonia pacifica*
- 19 Thallus with pigmented monosiphonous filaments 38. *Dasya kristeniae*
- 19: Thallus with unpigmented monosiphonous filaments (= trichoblasts) 20
 - 20 Thallus with secondary cortication obscuring the pericentral cells 21
 - 20: Thallus without secondary cortication, with visible pericentral cells 22 (*Polysiphonia*)

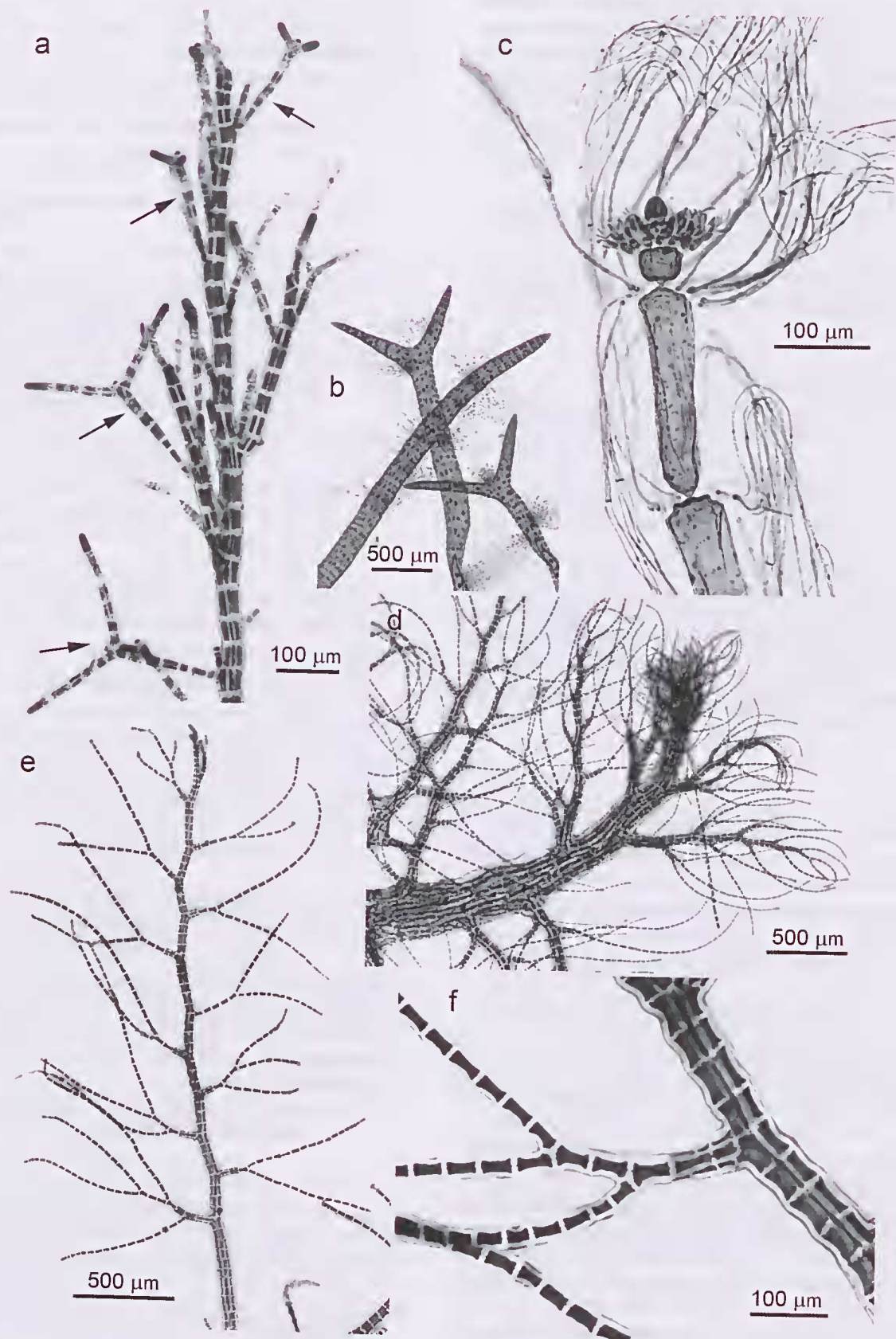


Figure 5. Phaeophyceae (a, b) and Rhodophyta (c–f). a. *Sphacelaria rigidula*, thallus habit with propagules (arrows). b. *Dictyota furcellata*, branch apices with surface hair clusters. c. *Anotrichium tenue*, branch apex showing whorled trichoblasts (colourless hairs). d. *Bostrychia flagellifera*, thallus habit with corticated primary axes tapering to uniseriate filaments. e, f. *Bostrychia moritziana*. e. thallus habit. f. detail showing uncorticated axes.

- 21 Branch apices blunt or with a sunken pit; pericentral cells persistent throughout thallus; spermatangia in plate-like structures 36. *Choudria succulenta*
- 21: Branch apices with a distinctly sunken pit; pericentral cells only obvious near branch apices; spermatangia not in plate-like structures 45. *Laurencia* sp.
- 22 Axes with 4 pericentral cells 23
- 22: Axes with more than 4 pericentral cells 24
- 23 Attachment rhizoids in open connection with bearing cell, thallus primarily prostrate 47. *Polysiphonia scopulorum*
- 23: Attachment rhizoids pit-connected to bearing cell, thallus primarily upright .. 46. *Polysiphonia infestans*
- 24 Thallus with extensive prostrate axes; with 6 pericentral cells throughout; attachment rhizoids in open connection with bearing cell 48. *Polysiphonia teges*
- 24: Thallus primarily upright; with 6 pericentral cells in primary axes, 5 pericentral cells in lateral branches; attachment rhizoids cut off from bearing cell 49. *Polysiphonia* sp.
- 25 Thallus with nodal cortication only 40. *Gayliella fimbriata*
- 25: Thallus with complete cortication at least in part 23
- 26 Cortication complete on primary axes, but nodal on lateral branches .. 50. *Spyridia filamentosa*
- 26: Cortication complete throughout 35. *Centroceras* sp.

25. *Aglaothamnion cordatum* (Børgesen) Feldm.-Maz. 1941: 459.

Thallus small, to 15 mm tall, uncorticated, alternately branched with a single lateral branch per axial cell, attached by a cluster of rhizoidal cells. Lower cells of primary axes 100–140 µm diam., often with L:B c. 1, occasionally more elongate. Mid-thallus cells 140–180 µm long and 50–80 µm diam., tapering to upper elongate cells 7–10 µm diam., occasionally with terminal hairs. Tetrasporangia on distal region of lateral branch cells, ellipsoidal, 40–45 × 30–35 µm, tetrahedrally divided.

Specimen: Little Lagoon, epiphytic on *Bostrychia tenella*, 6 June 2009, J.M.Huisman (PERTH 08578230).

The Shark Bay specimen was tetrasporangial and other reproductive structures were not observed. Without the carposporophyte generation the species is difficult to distinguish from *Seirospora orientalis*, but in *Aglaothamnion cordatum* the tetrasporangia are slightly smaller than those of *Seirospora*, and are ellipsoidal rather than spherical when mature.

26. *Anotrichium tenue* (C.Agardh) Nägeli 1862: 399.

Thallus tufted, with spreading prostrate axes attached by mostly unicellular rhizoids, with sparingly branched erect axes to 5 mm tall growing from the proximal ends of cells. Trichoblasts in whorls at apices, dichotomously to polychotomously divided. Cells of prostrate axes 170–200 µm diam. [L:B 2.5–3]; cells of erect axes of similar diameter, but shorter distally [L:B 1–1.5]. Reproductive structures not observed (Fig. 5c).

Specimen: Little Lagoon, 6 June 2009, J.M.Huisman (PERTH 08578257).

27. *Bostrychia flagellifera* E.Post 1936: 34.

Thallus prostrate with dense lateral branches, robust, mat-forming, dull purple to deep red. Primary axes 150–250 µm diam., bearing alternate lateral branches every 2–3 axial cells. Lateral branches polysiphonous proximally, 70–100 µm diam., bearing ultimate uniseriate branches 15–30 µm diam., these tapering distally with cells L:B 1–1.5 (Figs 2g, 5d).

Specimen: Blind Inlet, South Passage, 11 June 2009, J.M.Huisman (PERTH 08578303)

This species, described originally from the Paramatta River in New South Wales, is also known from New Zealand and Japan (Post 1961). King & Puttock (in King *et al.* 1988) treat it as a subspecies of *Bostrychia tenella*, and a previous Shark Bay record was under that name (Kendrick *et al.* 1990). Recognition at species level was recommended by Zuccarello & West (2006) based on molecular analyses that showed *B. flagellifera* did not group with *B. tenella*, and the taxon displays a diagnostic synapomorphy (branching interval).

28. *Bostrychia moritziana* (Sond. ex Kütz.) J.Agardh 1863: 862

Thallus prostrate, mat-forming, purple to brown; main axes indeterminate, 20–40 (–60) mm long, bearing determinate lateral branches 2–3 mm long, with 1–3 orders of alternate branching; 2 tiers of pericentral cells per axial cell with 4–5 (–8) pericentral cells per tier around the main axes and primary lateral branches; ecorticate throughout; polysiphonous except for monosiphonous ultimate and penultimate determinate branches. Indeterminate axes 60–100 µm diam.; branches arising subdichotomously at intervals of more than 10 axial cells; determinate branches arising laterally at intervals of 2–5 (–8) axial cells. (Figs 5e, f).

Specimen: Long Tom Bay, South Passage, 11 June 2009, J.M.Huisman (PERTH 08578435)

Recorded from Steep Point, Shark Bay (26°08'S., 113°10'E., iii.1986, Wells UNSW 16271) by King & Puttock (1989: 32)

29. *Bostrychia radicans* (Mont.) Mont. 1842: 661

Thallus prostrate with suberect branches, robust, turf-forming, purple to brown; main axes indeterminate, 10–15 (–20) mm long, bearing determinate lateral branches 2–3 mm long, with 1–2 (–3) orders of alternate branching; 2 tiers of pericentral cells per axial cell, with (5–) 7–8 pericentral cells per tier around the main axes and lateral branches, ecorticate and polysiphonous throughout; attached to the substratum by cladophylls. Indeterminate axes 120–200 µm diam.; branches arising subdichotomously at intervals of more than 10 axial cells; determinate branches arising laterally at intervals (2–) 4–6 axial cells (Fig. 6a).

Specimen: Uendoo Creek, 4 June 2009, J.M.Huisman (PERTH 08578516); also recorded from Steep Point, Shark Bay (26°08'S., 113°10'E., iii.1986, Wells UNSW 16269) by King & Puttock (1989: 32).

30. *Bostrychia tenella* (J.V.Lamour.) J.Agardh 1863: 869.

Thallus prostrate with dense lateral branches, robust,

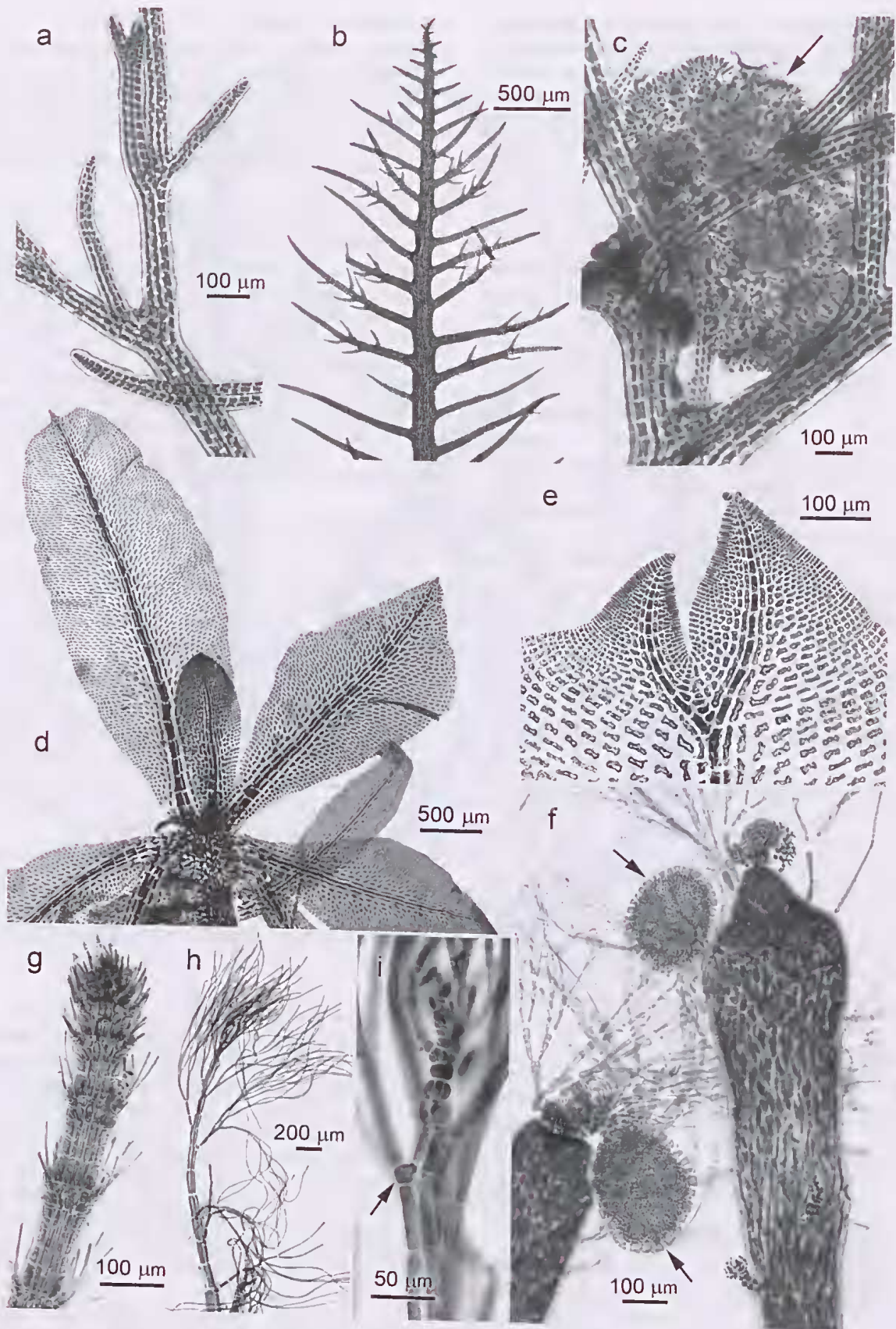


Figure 6. Rhodophyta. a. *Bostrychia radicans*, branch detail showing polysiphonous axes throughout. b. *Bostrychia tenella*, with regular alternate branches. c. *Bostrychiocolax australis* (arrow), forming a parasitic pustule on *Bostrychia radicans*. d. *Caloglossa leprieurii*, leafy branches with a distinct midrib. e. *Caloglossa* sp., apices with plate-like spermatangial branches (arrows). f. *Chondria succulenta*, thallus habit with polysiphonous main axis and pigment monosiphonous laterals. g. *Centroceras* sp., branch apices. h, i. *Dasya kristeniiae*. h. Thallus habit with polysiphonous main axis and pigment monosiphonous laterals. i. Detail of apex, showing quadrate basal cells of pigmented laterals (arrow).

mat-forming, dull purple, violet to brown; main axes indeterminate, 20–50 mm long, bearing determinate branches 2–3 mm long, with 1–3 (–4) orders of alternate branching; 2 tiers of 5–7 (–8) pericentral cells per axial cell; indeterminate axes and first-order lateral branches corticate; polysiphonous except for wholly or partially monosiphonous ultimate branches. Indeterminate axes 80–500 µm diam.; branches arising subdichotomously or laterally at intervals of 1 (–4) axial cells. Determinate branches arising at intervals of 1 (–2) axial cells. Tetrasporangial stichidia on ultimate lateral branches (Fig. 6b).

Specimen: Little Lagoon, 6 June 2009, *J.M.Huisman* (PERTH 08578249).

31. *Bostrychiocolax australis* Zuccarello & J.A.West 1994: 138.*

Thallus forming colourless irregularly shaped to hemispherical pustules laterally on host branches, to 600 µm tall and 900 µm broad. Structure filamentous, multiaxial, with darkly staining large internal cells bearing numerous radiating branches. Tetrasporangia terminal on filaments, ellipsoidal to obovoid, 20–30 µm long, 12–17 µm diam., tetrahedrally divided (Fig. 6c).

Specimen: Uendoo Creek, on *Bostrychia radicans* epiphytic on *Avicennia marina* pneumatophores, 4 June 2009, *J.M.Huisman* (PERTH 08578508).

This species is a parasitic red alga seemingly restricted to the host *Bostrychia radicans*. Two specimens were collected from the Uendoo Creek site, one male gametophyte and one tetrasporophyte. This represents a new generic record for Western Australia, the genus previously known only from Queensland (Zuccarello & West 1994: 138)

32. *Caloglossa leprieurii* (Mont.) G.Martens 1869: 234, 237.

Thallus forming low mats composed of arching leaf-like blades, pale brown to reddish brown, epiphytic and epilithic, loosely attached to the substratum at intervals by clusters of coalescent rhizoids arising from cortical pads produced by pericentral cells at the nodes; mature blades linear to suborbicular, (0.35–) 0.6–2.1 (–3.5) mm wide, with (0.8–) 3.1–6.2 (–7.5) mm between weakly to strongly constricted nodes, occasionally arising as stipitate rosettes; endogenous branches produced by an axial cell above the nodes; adventitious branches absent. Reproductive structures not observed (Fig. 6d).

Specimen: Wooramel, 5 June 2009, *J.M.Huisman* (PERTH 08578524); Faure I., 10 June 2009, *J.M.Huisman* (PERTH); also recorded from Shark Bay by West *et al.* 2001

33. *Caloglossa monosticha* M.Kamiya in M.Kamiya, J.Tanaka & Y.Hara 1997: 105.

Thalli forming low mats composed of arching blades, pale brown to olive-green, epiphytic, subdichotomously branched, loosely attached to the substratum at intervals by clusters of divergent rhizoids arising directly from nodal pericentral cells; mature blades linear to narrowly elliptical, 0.3–1.4 mm wide with 1.3–5.8 mm between slightly constricted nodes; stipes absent. Nodes on main

axes with all second- and third-order cell rows on the adjacent and opposite sides reaching the blade margin. Rhizoids arising from first and second adjacent and adaxial lateral pericentral (second-order) cells above the node, 6–10 cells and 0.6–1.5 mm long, 25–45 µm diam. Reproductive structures not observed (Fig. 6e).

Specimen: Dubaut Creek, 8 June 2009, *J.M.Huisman* (PERTH 08578354); also recorded from Monkey Mia, Shark Bay, by West *et al.* (2001: 192).

Caloglossa monosticha can be distinguished from *C. leprieurii* by the attachment rhizoids remaining free and not forming a stipe. This feature is best observed in well-developed specimens, as rhizoids in young branches of *C. leprieurii* are also free. A further distinction can be seen in the cell arrangement at nodes. In *C. leprieurii* the basal axial cell of the lateral branch lacks an adaxial pericentral cell, whereas these are present in *C. monosticha*. Wynne & De Clerck (1999) proposed that *C. monosticha* was conspecific with the earlier described *C. saigonensis* Tak.Tanaka & P.H.Hô, but this was rejected by Kamiya *et al.* (2003) based on molecular and culture studies.

34. *Catenella uipae* Zanardini 1872: 143.*

Thallus dark red to brown, to 4 cm tall, tufted or tangled, with sprawling terete stolons to 0.5 mm wide, attached at several points. Erect axes richly branched, segmented; segments elongate-ovoid, 3–5 mm long, 0.5–1.0 mm wide. Structure with a prominent apical cell but usually lacking a single distinct axial filament; centre of the medulla occupied by several longitudinal filaments, each with a single lateral filament, these forming a reticulate medulla of regularly spaced branched filaments 10–25 µm diam., often with stellate cells. Secondary connections between medullary filaments common. Cortex of 2 cell layers; inner layer of clavate to spherical cells; outer layer of ellipsoidal to elongate cells 3.5–7.0 µm diam., forming a palisade. Spermatangia in sori on thallus surface. Other reproduction not observed (Figs 7a, b).

Specimen: Uendoo Creek, 4 June 2009, *J.M.Huisman* (PERTH 08578532).

The present specimens agree in most respects with the description by Min-Thein & Womersley (1976), excluding the presence of two periaxial cells per axial cell, a feature regarded as characteristic for the genus (Guiry & Guiry, 2014). Later, however, Womersley (1994), described only one periaxial cell per axial cell. The primary axial filament in the Shark Bay specimens was often conspicuous, particularly so in material stained with aniline blue, this also differing from Womersley's description who suggested that the axial filament was inconspicuous. The persistent visibility of the axial filament is a feature of the closely related *Caulacanthus ustulatus*, but that species is not constricted. One of the specimens was male, with spermatangia produced in sori on the thallus surface.

35. *Centroceras* sp.*

Thallus with prostrate and assurgent axes, light red, to 3.5 mm tall, sparsely subdichotomously branched every c. 8 cells, but often with long unbranched axes. Prostrate axes attached by multicellular rhizoids arising 1–3 per

node from periaxial cells, basally as an extension of the periaxial cell and the first cross wall external to the node. Upright axes with forcipate apices. Segments 70–90 µm diam. [L:B < 1 near apices, to 5 in mature segments]. Periaxial cells 8–11 per node, each bearing 2 acropetal and 1 basipetal initials. First acropetal initial bearing either a spine or a gland cell, and 1 or 2 conical to elongate cells, these often forming elongate hairs. Second acropetal initial bearing 1 acropetal conical to elongate cell and a basipetal cortical filament. Basipetal initial bearing 1 basipetal cortical filament. Spines 2-celled (not including acropetal initial), in whorls of 4–6 per node. Gland cells ellipsoidal, 10–12 µm long, 7–10 µm diam. Basipetal cortical filaments 10–12 cells long, completely covering the axial cells, with cells of varying lengths, these often becoming transversely aligned towards the proximal portion of each segment (Fig. 6g).

Specimen: Wooramel, 5 June 2009, *J.M.Huisman* (PERTH 08578397).

This is a new species, known also from Barrow Island, the Rowley Shoals, and Scott Reef, which is being formally described elsewhere (Huisman, in prep.).

36. *Chondria succulenta* (J.Agardh) Falkenb. 1901: 205–206, pl. 22: figs. 22, 23.*

Thallus with several simple to 1–3 times branched axes arising from a common holdfast, to 6 mm tall. Axes terete, 0.25–0.6 mm diam., with blunt to sunken apices with emergent filaments. Epidermal cells elongate to ellipsoidal, 17–20 µm diam. L:B to 7. Tetrasporangia near apices, spherical, 50–75 µm diam., tetrahedrally divided. Spermatangia in discoid plates, to 450 µm broad, with a single row of sterile marginal cells (Fig. 6f).

Specimen: Little Lagoon, 6 June 2006, *J.M.Huisman* (PERTH 08578346).

Although of only a small stature, both male and tetrasporic specimens were collected. These agree for the most part with the description by Gordon-Mills & Womersley (534–537), differing only in the smaller size of the thallus and tetrasporangia. In both cases this is probably due to the plant maturity.

37. *Crouania* sp.

Thallus filamentous, uncorticated, with prostrate and erect branches. Erect branches c. 750 µm tall, with axial cells 10–15 µm diam., L:B 1.5–2, each axial cell bearing a whorl of 3 branches, these 2–3 cells long and dichotomously branched (in one instance trichotomous). Reproductive structures not observed.

Specimen: Wooramel South, epiphytic on *Bostrychia tenella*, 5 June 2009, *J.M.Huisman* (PERTH 08578389; PERTH 08578613).

These are immature specimens that cannot be identified to species.

38. *Dasya kristeniae* I.A.Abbott 1998: 105.*

Thallus red, 9 mm tall, attached by clumped pigmented cells arising from the basal region. Primary axis polysiphonous, terete, basally to 200 µm diam., tapering to 50 µm diam. near apices, with sympodial apical

growth and pericentral cells developing spirally. Primary axial cells each with 5 pericentral cells and a branched, pigmented monosiphonous lateral arising in a 2/5 spiral. Segments of primary axis elongate, L:B 2–4. Monosiphonous laterals to 1.5 mm long, monopodial, dichotomously branched every 1–2 cells, with elongate cells 10–20 µm diam., L:B 5–7. Reproductive structures not observed (Figs 6h, i).

Specimen: Little Lagoon, epiphytic on *Polysiphonia teges*, 6 June 2009, *J.M.Huisman* (PERTH 08578567).

This small species is attributed to *Dasya* based on the production of five pericentral cells, sympodial growth of primary axes, and branched, monosiphonous pigmented laterals arising on every segment in a 2/5 spiral. Unlike most species of the genus, however, the pigmented lateral branches divide monopodially, and thus do not have dichotomies wherein the two distal cells have a confluent lateral face (the 'inverse Y junction' described by Parsons 1975: 562). Although this was not described by Abbott (1998, 1999), her figures of *Dasya kristeniae* appear to show a similar arrangement. Abbott (1998) described *D. kristeniae* as having only four pericentral cells, but also as having monosiphonous laterals arising in a 2/5 spiral, which is incompatible with four pericentral cells. Coppejans & Millar (2000: 329) attributed completely ecorticate (except for small rhizoids at the very base) plants from Papua New Guinea to *D. kristeniae*, although they did not comment on the number of pericentral cells.

39. *Erythrotrichia carnea* (Dillwyn) J.Agardh 1883: 15.*

Thallus red to purple-red, with erect filaments to 3 mm tall, attached by a single basal cell that can be lobed. Filaments mostly simple, 15–20 µm diam. (including a thick gelatinous wall); cells 12–14 µm long [L:B 0.7–1]. Monosporangia subspherical, cut off by a curved wall.

Specimen: Cape Lesueur, epiphytic on *Gayliella fimbriata*, 7 June 2009, *J.M.Huisman* (PERTH 08578605).

E. carnea forms small, unbranched, uniseriate filaments, epiphytic on a variety of algae. It is a common and widespread species.

40. *Gayliella fimbriata* (Setch. & N.L.Gardner) T.O.Cho & S.M.Boo in T.O.Cho *et al.* 2008: 723.*

Thallus red to purple-red, with prostrate and erect axes to 7.5 mm long, attached by rhizoids arising from periaxial cells of lower axes. Erect axes subalternately branched every 4 or 5 cells in the primary axes and every 5–7 cells in lateral axes. Apices straight to curved, not circinate. Periaxial cells 6, each producing basipetally a transversely aligned cell that subsequently cuts off 1 or 2 cells by oblique divisions from the lower corners, and acropetally a pair of cells that divide several times. Cortical cell development more extensive in older nodes. Distal cells of nodes commonly with elongate or clavate gland cells. Reproductive structures not observed (Fig. 7c).

Specimen: Cape Lesueur, 7 June 2009, *J.M.Huisman* (PERTH 08578362).

The genus *Gayliella* was erected by Cho *et al.* (2008) for several species previously placed in *Ceramium*, but which

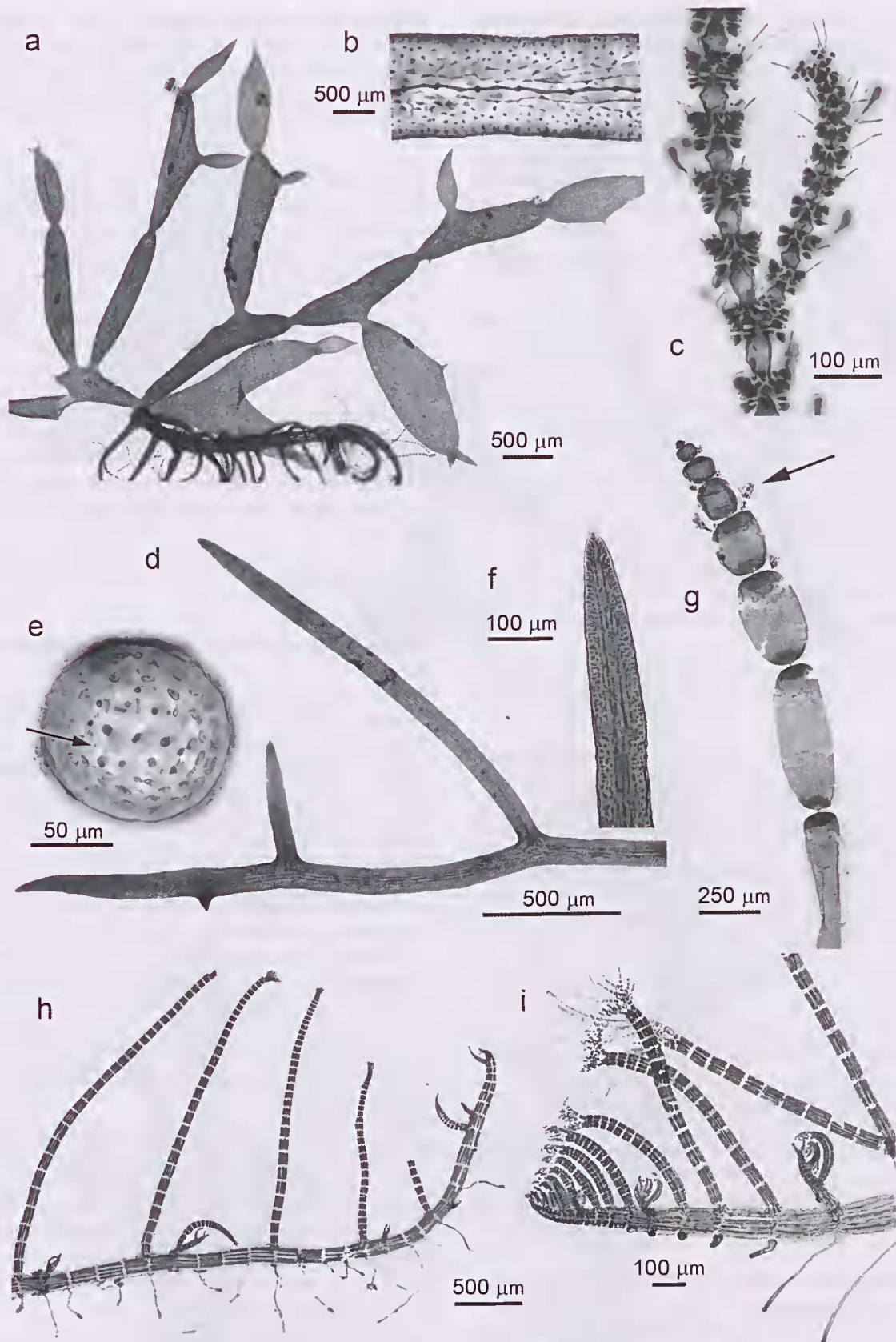


Figure 7. Rhodophyta. a, b. *Catenella nipae*. a. habit showing characteristic segmented thallus. b. showing obvious central axis. c. *Gayliella fimbriata*, detail of thallus showing filamentous construction with nodal cortication. d–f. *Gelidium minusculum*. d. Plant habit showing prostrate axis and simple upright axes. e. Transverse section of thallus showing rhizines at the medulla/cortex interface (arrow). f. Closer view of thallus showing pointed apex with a single apical cell. g. *Griffithsia heteromorpha*, habit. Note trichoblasts on upper cells (arrow). h. *Herposiphonia pacifica*, habit, showing prostrate axis with a simple determinate branch proximal to an indeterminate branch. i. *Herposiphonia tenella*, habit, showing regular pattern of three determinate branches and one indeterminate branch.

resolved in a segregate clade in molecular analyses and differed in having transversely aligned basipetal cortical cells. Prior to this, *Gayliella fimbriata* (as *Ceramium*) was one of several species thought to belong to a widespread, morphologically variable species *Ceramium flaccidum* (now *Gayliella flaccida*) (Womersley 1978). Thus many records of the latter, including those from Shark Bay (Huisman *et al.* 1990: 96; Kendrick *et al.* 1990: 51) are possibly incorrect and should be re-assessed.

41. *Gelidium minusculum* (Weber Bosse) R.E.Norris 1992: 17.*

Thallus forming creeping prostrate axes attached by clustered rhizoids, bearing sparse, perpendicular erect axes approximately every 500–700 μm , although these often more frequent or absent for long distances. Prostrate axes terete, to 150 μm diam. Upright axes terete, to 1–4 mm tall, 80–100 μm diam., mostly simple, with pointed apices. Structure uniaxial, when mature with a medulla of longitudinal filaments, these cross-linked by pit-connections, and a cortex of 2–4 layers of smaller pigmented cells. Outer cells rounded to transversely elongate in surface view, 12–18 μm long, 5–8 μm broad, in vague, meandering longitudinal lines. Rhizines inconspicuous, in small bundles at the medulla/cortex interface. Reproductive structures not observed (Figs 7d–f).

Specimen: Uendoo Creek, epiphytic on *Avicennia marina* pneumatophores, 4 June 2009, J.M.Huisman (PERTH 08578656).

This small, wiry species with cylindrical branches was originally described (but not illustrated) based on specimens from Indonesia (Weber-van Bosse 1921: 226, as *Gelidium pusillum* var. *miniscula*). Hatta & Prud'homme van Reine (367, fig. 9A) illustrated a plant that was collected as a mangrove epiphyte from Sumba, Indonesia. The taxon was subsequently recorded from South Africa and raised to species level by Norris (1992), who regarded *G. pusillum* (*sensu stricto*) to be considerably more restricted in distribution than previously believed. A subsequent study by Millar & Freshwater (2005) supported this view of *G. pusillum*, but referred the South African taxon to *Gelidium isabelae* Taylor. The Shark Bay specimens have uniformly terete branches that are never flattened, similar to the mangrove epiphyte described by Hatta & Prud'homme van Reine (1991: 368, table 3), but differing from the lagoonal plants with spatulate upright branched described by those authors. Flattening of branches in *Gelidium* often occurs when they become reproductive, however, and the Shark Bay specimens were vegetative only.

42. *Griffithsia heteromorpha* Kütz. 1863: 2, pl. 3, figs a, b.*

Thallus red, filamentous, 3.5 mm tall, attached by rhizoids and cells arising from lower cells. Lower cells cylindrical to clavate, 100–200 μm diam., L:B ± 4 , grading to upper barrel-shaped to spherical cells 200–250 μm diam., L:B ± 1 , then tapering to apical cells. Upper cells each with 2–3 distal trichoblasts. Reproductive structures not observed (Fig. 7g).

Specimen: Little Lagoon, epiphytic on *Centroceras* sp., 6 June 2006, J.M.Huisman (PERTH 08578338).

Griffithsia heteromorpha is similar in form to other species of the genus and is distinguished by its tetrasporangia lacking an involucre (protective branches). The present specimen is immature and lacks this feature, but morphologically accords with this common species.

43. *Herposiphonia pacifica* Hollenb. 1968b: 549.*

Thallus red, attached by unbranched unicellular rhizoids, with digitate tips arising from the distal end of ventral pericentral cells. Indeterminate prostrate axes with circinate apices, with indeterminate axes arising laterally on alternate sides every 3 or 4 segments. Determinate lateral branches arising dorsally every 3 segments, 1 segment proximal to the indeterminate lateral branch. Prostrate axes terete, 130–145 μm diam. [segment L:B c. 1], with 8–11 pericentral cells. Determinate branches initially curved but becoming straight, unbranched, to 35 segments long when mature, terete, 80–100 μm diam. [segment L:B mostly 1–1.5], with 8–11 pericentral cells. Determinate axes with well-developed apical trichoblasts to 1.6 mm long, dichotomously divided to 7 times. (Fig. 7h).

Specimen: Uendoo Creek, 4 June 2009, J.M.Huisman (PERTH 08578540).

44. *Herposiphonia tenella* (C.Agardh) Ambronn 1880: 197.

Thallus red, with prostrate indeterminate and erect determinate axes, attached by unbranched unicellular rhizoids arising from the distal end of ventral pericentral cells. Indeterminate prostrate axes with circinate apices, with a regular sequence of 3 determinate and 1 indeterminate lateral branches; determinate axes arising dorsally or dorso-laterally, but erect; indeterminate axes ventro-lateral and prostrate. Prostrate axes terete, 100–110 μm diam. [segment L:B c. 1], with 9 or 10 pericentral cells. Determinate branches initially curved but straightening, unbranched, 1.5–2.5 mm long, with 9–11 segments when mature, terete, 60–75 μm diam. [segment L:B mostly 1–4], with 6–9 pericentral cells. All axes with terminal trichoblasts, these dichotomously divided, with tapering unpigmented cells. Cells with numerous spherical plastids, these often pectinate (Fig. 7i).

Specimen: Cape Lesueur, 7 June 2009, J.M.Huisman (PERTH 08578788).

This species, the generitype, is often treated as a form of *Herposiphonia secunda* (C.Agardh) Ambronn (see Wynne 1985), but recent studies have regarded it as a distinct species (Schneider & Searles, 1997; Masuda & Kogame 2000). It is characterized by the regular sequence of determinate and indeterminate branches.

45. *Laurencia* sp.

Thallus with several simple to once-branched axes arising from a common holdfast, to 8 mm tall. Axes terete, 0.25–0.5 mm diam., with blunt apices and an apical pit with emergent filaments. Epidermal cells with longitudinal pit connections, in surface view rounded to ellipsoidal, 20–50 μm diam. Tetrasporangia with parallel arrangement near apices, spherical, 100–130 μm diam., tetrahedrally divided (Fig. 8a).

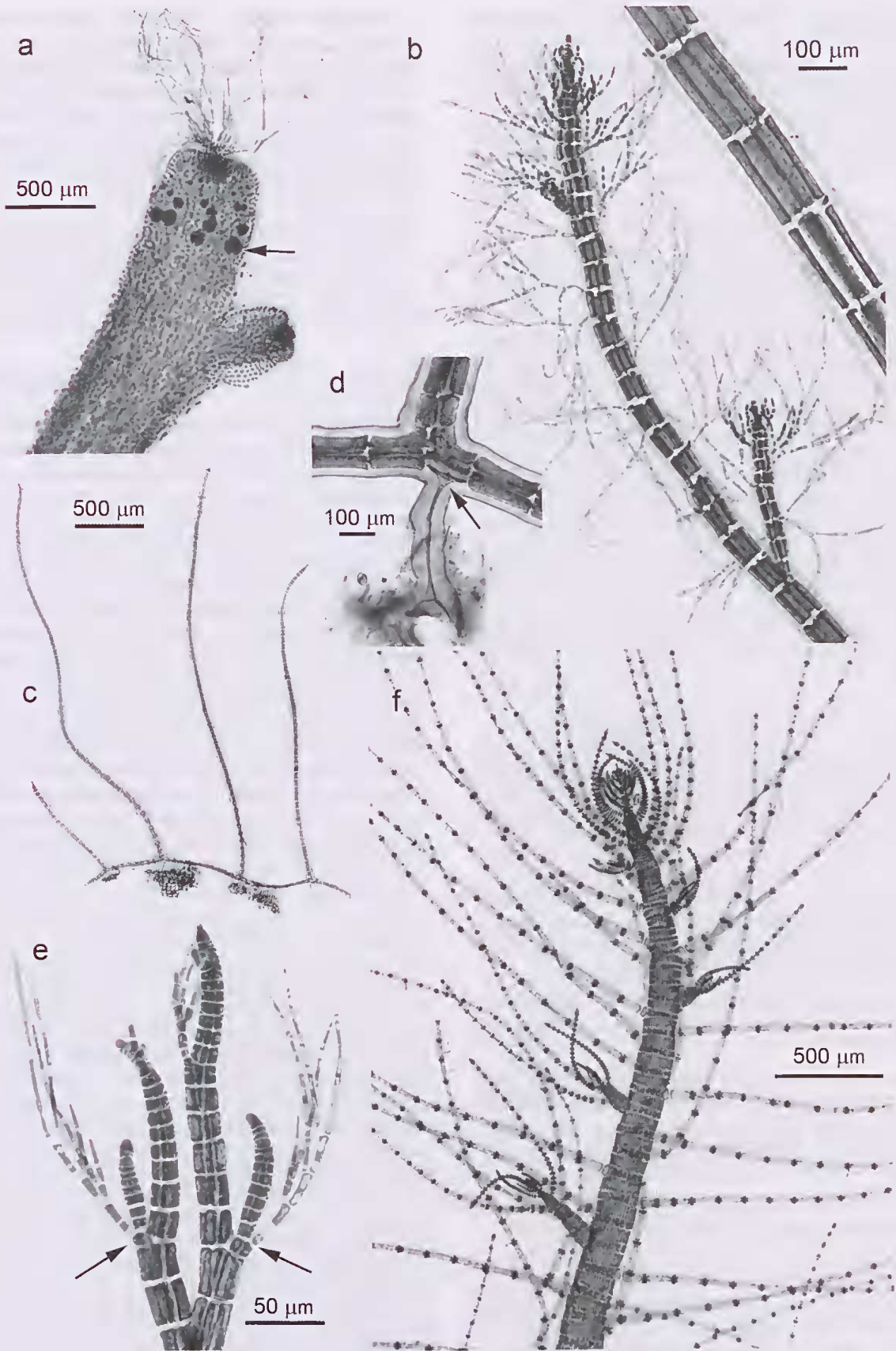


Figure 8. Rhodophyta. a. *Laurencia* sp., branch apex with tetrasporangia (arrow). b. *Polysiphonia infestans*, branch apex showing trichoblasts and (at right) a portion of an older branch, showing considerable variation in branch width. c, d. *Polysiphonia scopulorum*. c. Thallus habit, with prostrate axes and simple upright branches. d. Detail of attachment rhizoids in open connection with bearing cell (arrow). e. *Polysiphonia* sp., branch apices showing origin of lateral branches in axils of trichoblasts (arrows). f. *Spyridia filamentosa*, thallus habit, with fully corticated primary axis bearing lateral filaments corticated only at nodes.

Specimen: Little Lagoon, 6 June 2009, *J.M.Huisman* (PERTH 08578265).

These plants are reproductively mature but show few diagnostic features. They agree with *Laurencia intricata* J.V.Lamour. as described by Price & Scott (1992), but we defer specific placement until more luxuriant specimens are available.

46. *Polysiphonia infestans* Harv. 1855: 539.

Thallus red, primarily erect, to 16 mm tall, or with limited prostrate axes, attached to the substratum by unicellular digitate rhizoids arising from basal cells of primary axes. Erect axes subdichotomously branched every 5–10 segments. Axes with 4 pericentral cells and a trichoblast/scar cell on each segment in a spiral pattern with a 1/4 divergence between successive segments. Lower segments 390–430 µm diam. (including wall to 100 µm thick) [L:B 0.4–0.5 (c. 1 if the wall is excluded)]; mid-thallus segments 100–170 µm diam. [L:B 1–1.3 (–3)], tapering gradually to upper segments 40–75 µm diam. [L:B 1–1.2]. Lateral branches replacing trichoblasts. Spermatangia in cylindrical to lanceolate heads forming as one branch of a basal dichotomy of trichoblasts, 170–290 µm long, 40–45 µm diam., without a sterile apical cell (Fig. 8b).

Specimen: Wooramel South, 5 June 2009, *J.M.Huisman* (PERTH); Faure I., 10 June 2009, *J.M.Huisman* (PERTH 08578311).

47. *Polysiphonia scopulorum* Harv. 1855: 540.

Thallus with well-developed prostrate axes, 80–100 µm diam., attached by unicellular rhizoids in open connection with bearing cell. Upright axes to 3 mm tall, often arising from segments adjacent to rhizoids, 50–100 µm diam., simple to sparsely branched, trichoblasts rudimentary at apices, soon deciduous. All axes with 4 pericentral cells. Scar cells occasionally present. Pericentral cells equidimensional near apices, forming segments L:B 0.3–0.5; lower segments L:B 0.8–1. Reproductive structures not observed (Figs 8c, d).

Specimen: Uendoo Creek, 4 June 2009, *J.M.Huisman* (PERTH). Little Lagoon, 6 June 2009, *J.M.Huisman* (PERTH 08578559).

The extensive prostrate axes, 4 pericentral cells per axial cell, and attachment rhizoids in open connection to the parent cell are characteristic of this species (Womersley 1979: 467–469). It is similar to *Polysiphonia teges* (see below), but that species has 6 pericentral cells.

48. *Polysiphonia teges* Womersley 1979: 494, fig. 10A–C.*

Thallus with prostrate axes, 90–100 µm diam., attached by unicellular rhizoids in open connection with bearing cell. Upright axes to 9 mm tall, 75–100 µm diam., sparsely branched, trichoblasts rudimentary at apices, soon deciduous. All axes with 6 pericentral cells, these generally slightly rounded. Scar cells occasionally present. Segment L:B generally ≤ 1, rarely longer. Reproductive structures not observed.

Specimen: Little Lagoon, 6 June 2009, *J.M.Huisman* (PERTH 08578621).

49. *Polysiphonia* sp.*

Thallus 32 mm tall, mostly upright, attached by thin rhizoids arising from pericentral cells near base. Axes 300–350 µm diam. near base, segment L:B ±0.6, tapering gradually to mid thallus 150 µm diam., L:B ±1, then to upper branches 50 µm diam., L:B 2–2.5. Axes with 6 pericentral cells in primary axes, 5 pericentral cells in lateral branches and minor axes. Trichoblasts present near apices, 300–600 µm long, 2–3 times subdichotomously divided, with hyaline cells. Lateral branches arising every 7–15 segments, initially in axils of trichoblasts, slightly narrowed at branch base. Scar cells at intervals of 2–6 segments, occasionally at regular intervals of 3 or 4. Reproductive structures not observed (Fig. 8e).

Specimen: Wooramel central, 5 June 2009, *J.M.Huisman* (PERTH 08578818).

This specimen possibly represents a new species. The combination of 5–6 pericentral cells, lateral branches arising in association with trichoblasts, and the irregular occurrence of scar cells does not appear to have been described previously, certainly not for any species recorded for Australia (Cribb 1983; Price & Scott 1992; Womersley 1979). It appears to be similar to *Polysiphonia homoia*, a species described originally from Isla Guadalupe, Mexico (Setchell & Gardner 1930), but since recorded from several other tropical locations in the Pacific (Hollenberg 1968a, Abbott 1999, N'Yeurt & Payri 2010). Hollenberg commented on some important differences between his material and the type, which suggests that more than one taxon might be involved. Setchell & Gardner (1930: 162) stated that *P. homoia* was 'constantly 5-siphonous' (i.e. with 5 pericentral cells), which differs from the Shark Bay specimen which had 6 pericentral cells in major axes. Unfortunately reproductive specimens were not collected and we defer any taxonomic decisions until additional material is available.

50. *Spyridia filamentosa* (Wulfen) Harv. 1833: 337.

Thallus to 10 cm tall. Growth from a prominent apical cell, producing a series of short cells before initiation of nodal cortication. Determinate or indeterminate lateral branches arising singly from each axial cell in a spiral pattern, or adventitiously from cortical cells. Primary axes with a ring of 10–14 cells at the nodes, these dividing basipetally to form a ring of longitudinally elongate cells covering the internodal region. Primary axes thus with alternating bands of broad and narrow cells, later mixed with corticating rhizoids. Determinate laterals 20–25 cells long, initially with short cells and attaining full cell number before producing nodal cortication, often with a terminal spinous cell but this generally lost. Mature determinate branches 1.5–2.0 mm long, with cells 30–55 µm wide [L:B to 4–5], and nodal cortication of 6–8 cells, these dividing to form a band of 1 or 2 (rarely 3) layers. Tetrasporangia arising singly or in sequentially maturing pairs on the adaxial surface of determinate branch nodal cells, sessile, pyriform when young but becoming spherical, 60–72 µm diam. (including wall 10–12 µm thick), tetrahedrally divided. Other reproductive structures not observed (Fig. 8f).

Specimen: Faure I., 10 June 2009, *J.M.Huisman* (PERTH 08578281).

51. *Stylonema alsidii* (Zanardini) K.M.Drew 1956: 72.*

Thallus erect, usually epiphytic, inconspicuous, to 500 µm tall, pseudofilamentous, branched, uniseriate. Cells within a conspicuous mucilaginous sheath, 15–25 µm diam., this often not obvious near the apices but conspicuous near the base and 2–3 times the diameter of the cells; cells 7–10 µm diam. [L:B 0.5–2.0], mostly cylindrical, but basal cells of branches tapering proximally.

Specimen: Wooramel, epiphytic on *Acetabularia peniculus*, 5 June 2009, J.M.Huisman (PERTH 08578729).

A small, uniseriate epiphyte, possibly more widespread than the present records indicate.

DISCUSSION

The present account records 51 species of marine algae and cyanobacteria from the pneumatophores of the mangrove *Avicennia marina* in Shark Bay, Western Australia. Of these, the vast majority (31) represent new records for the bay, with three species also newly recorded for Western Australia. These observations most likely reflect the relative paucity of collections from the region, and are not indicative of newly introduced species. The macroalgae of Shark Bay are represented in the Western Australian Herbarium (PERTH) by only 212 specimens, mostly collected by JMH or Gary Kendrick and Diana Walker as part of the University of Western Australia's research program in the 1980s. None of these specimens are mangrove epiphytes, and the group was similarly overlooked in the collation of records presented in Huisman *et al.* (1990). Thus the surfeit of new records presented here is to be expected following the initiation of interest in the region's mangrove-associated flora.

The range of taxa recorded is remarkably similar to that reported from mangals elsewhere in Australia (e.g. Saenger *et al.* 1977, Davey & Woelkerling 1980; Beanland & Woelkerling 1982; King & Wheeler 1985) and worldwide (e.g. Lambert *et al.* 1987; West 1991; Skelton & South 2002; West *et al.* 2013). The flora includes species of *Bostrychia*, *Caloglossa*, and *Catenella*, which, while none are obligate, are almost universally recorded as part of mangrove floras (King 1981). Other genera recorded for Shark Bay that were also recorded for N.S.W. mangroves by King & Wheeler (1985) include *Erythrotrichia*, *Polysiphonia*, *Spyridia*, *Sphacelaria*, *Chaetomorpha*, *Cladophora*, *Ulva*, *Rhizoclonium*, and *Gayralia* (as *Ulvaria*). These taxa, however, are commonly found as epiphytes on a range of seagrasses and larger macroalgae and are best considered as generalists.

Mangrove habitats are typically regarded as having a low diversity of epiphytes, and this was commented on by King (1981: 322), who suggested that these habitats are unfavourable due to a lack of stable substratum (excluding the mangroves), mud in suspension, and the physiological stress placed on algae in a situation of fluctuating salinity. King (1981: 322) also suggested that the "algal flora of marshes and mangals is depauperate and dull", resulting in little incentive for floristic studies. Despite this, King himself devoted much of his life to studying the mangrove algal flora, and phycologists such as John West (University of Melbourne) and Joe

Zuccarello (Victoria University of Wellington) have used molecular and culture studies to tease out the minutiae of the biology of mangrove epiphytes such as *Bostrychia* and *Caloglossa*, resulting in several landmark studies (e.g., Zuccarello & West 2006). Despite (or perhaps because of) the limited diversity of mangrove-associated algae, the group has been the subject of considerable interest and provided model organisms for life history and taxonomic studies.

The presence of 51 species at Shark Bay is comparable to the 32 recorded for N.S.W. by King & Wheeler (1985, not including cyanobacteria), 49 for South Australia by Beanland & Woelkerling (1982), and 22 species by Davey & Woelkerling (1980) for Victoria. While those diversity estimates might seem small in comparison to the corresponding local floras, the marine benthic flora of Shark Bay was given at only 153 species by Huisman *et al.* (1990), the low number undoubtedly an underestimate but also a clear reflection of the lack of hard substrata in the bay. Thus the mangrove community, with almost a quarter of the now known Shark Bay flora, represents a significant contributor to the bay's macroalgal diversity.

While this study aimed to document this algal community, we did notice marked differences in the diversity of algal flora at some sites, including some where the pneumatophores were essentially devoid of algae. The occurrence of species did not exhibit any consistent broad scale patterns across the study sites, and such differences may relate to site-specific factors like tree size and canopy density. As this study was essentially a qualitative snapshot of this community based on sampling over several days, it would be beneficial if further ecological research was undertaken to examine factors that influence the composition and distribution of this poorly known community.

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